Final Report

Contract DC-1714

Design Study of Omni-environmental Protective Assembly

Phase I - Helmet Development

19 July 1972

 OSA - 1951-71

JEF-328-2435

10 August 1971

TO: Headquarters (4 copies)

Info: WR

SUBJECT: Proposal for a Design Study
Omni-environmental Protective Assembly

1.0 Purpose

The primary purpose of the study is to determine the feasibility of improving the current active Full Pressure Pilots Protective Assemblies (S1010, S901J, A/P22S-6). Included in the purpose is the objective to determine the degree of multi-mission capability which might be achieved with a single basic protective assembly using interchangeable components, such as exterior covers, for adapting to aircraft types not commonly equipped with identical ejection seats, etc.

The secondary purpose, not necessarily in the degree of importance, is to study the design of the protective assemblies for improved reliability and maintainability.

2.0 Scope

The study will include considerations for the types of missions flown, aircraft used, and environmental conditions to which the aircrews are exposed throughout the period from donning to doffing of the protective assembly.

With respect to maintainability, the scope of the study will include analysis of preflight and postflight activity as well as on-going experience in Field Level and Special Repair Activity (SRA) maintenance, with the objective of improving reaction time for missions.

Experience obtained through utilization of the protective assemblies now being used will be employed in development of the proposed design.

3.0 Definition

Omni-environmental Protective Assembly (OEPA) as used in this proposal is defined as a system used to protect aircrews which operate the current series of USAF aircraft used in sustained high altitude operations (in excess of 50,000 feet). The environment in which operations are conducted and protection is to be afforded includes the following:

3.1 Preflight operating area (including transfer from buildings to flight lines and vice versa.

3.2 Airborne environment (aircraft cockpit).

3.3. Airborne environment (free fall and parachute descent).

3.4 Land survival (Temperate, Frigid and Torrid Zones).

3.5 Sea survival (Temperate, Frigid and Torrid Zones).

STAT 4.0 Requirements for OEPA Design (reference [redacted] Msg 1529 3/17/71, letter 7/6/71 and [redacted] Msg 9932 7/19/71 STAT

Operational experience indicates that improvements and/or added capabilities are desired in the following areas:

4.1 Helmet

4.1.1 Visibility, especially in the vertical plane (relocate breathing regulator).

4.1.2 Head mobility in the horizontal plane.

4.1.3 Helmet comfort and ventilation.

4.1.4 Emergency face plate heat.

4.1.5 Breathing oxygen pressure warning or hypoxia indicator.

4.1.6 Visor anti-reflectance coating.

4.1.7 Helmet locking feature.

4.1.8 Face barrier and face seal.

4.1.9 Helmet disconnect (increase inside diameter).

4.1.10 Feeding port.

4.1.11 Communication/electrical cord penetrations and routings.

4.1.12 Microphone mounting.

4.2 Coverall

4.2.1 Integration of controller, regulator, ventilation inlet fitting, and communication/electrical penetration fittings to achieve better accessibility and maintainability and to reduce weight and bulk,

4.2.2 Main entry design, to provide easier donning and doffing.

4.2.3 Bladder cloth boots.

4.2.4 Sizing adjustability for standard and custom-sized OEPA's.

4.2.5 Vent flow control valve and hose assembly.

4.2.6 Reliability of the UCD.

4.2.7 Holddown assembly.

4.2.8 Reliability of the pressure sealing closure.

4.2.9 Flotation garment.

4.2.10 Comfort of the integrated harness.

4.2.11 Flammability protection.

4.2.12 Develop the OEPA design for adaptability to single or dual oxygen system.

4.3 Gloves

4.3.1 Glove design.

5.0 Study Plan

5.1 Phases

The study program is proposed to be conducted in two phases: Phase I, Helmet; Phase II, Coverall and Gloves.

5.1.1 Phase I

A design plan for an improved helmet will be developed which will incorporate the requirements listed under paragraph 4.1. In support of the design plan, a prototype helmet will be fabricated which will be suitable for use in low pressure chamber flights for evaluating the more critical aspects of the requirements for which the design plan will be submitted.

In support of the effort under this phase the contractor proposes that S1010 PPA identified as number 400 be used for modification as required to obtain a prototype helmet in the shortest period of time and in the most economical manner.

It is not proposed herein that a hypoxia indicator or pressure warning device nor a visor with anti-reflectance coating will be furnished with the prototype unit. A configuration with performance parameters for these two areas will be included in the design plan.

5.1.2 Phase II

The requirements listed under paragraph 4.2 above will be studied in detail with a design plan to be developed for improved coverall and gloves. This phase of the study will utilize the results of Phase I in developing the design which will be presented as the OEPA. A prototype OEPA will be developed for evaluation of the more critical aspects of the requirements. This prototype would be for use in low pressure chamber flights only. The availability of the helmet delivered under Phase I is assumed.

6.0 Program Schedule

6.1 Phase I

The contractor proposes that this phase will be completed within six months after receipt of authorization to proceed.

6.2 Phase II

The contractor proposes that this phase be completed within 12 months after authorization to proceed.

7.0 Level of Effort

Direct labor hours by categories and phases is as follows:

7.1 Phase I (3745 hours)

Mechanical Engineer	900
Pattern Designer	250
Modelmaker	550
Draftsman	900
Assembly Technician	200
Test Technician	175
Stitcher	60
Cementer	70
Machinist	470
Link-net Gridder	20
Link-net Assembler	20
Quality Assurance Technician	85
Mark and Cut	20
Molding	25

7.2 Phase II (4135 hours)

Mechanical Engineer	850
Pattern Designer	600
Pattern Grader	700
Draftsman	280

Assembly Technician	100
Test Technician	50
Stitcher	150
Cementer	150
Machinist	400
Link-net Gridder	400
Link-net Fabrication	220
Link-net Assembly	60
Mark and Cut	25
Molding	15
Quality Control Technician	135

8.0 Price Proposal

We propose a Fixed Price Level of Effort Type Contract. The attached Schedule provides a breakdown for labor and materials for the study program. The cost of materials is based on the assumption that the S1010 PPA number 400 will be available for modification as proposed in paragraph 5.2.

Very truly yours,

[redacted] STAT

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Enclosure

COST BREAKDOWN

DESIGN STUDY

OMNI-ENVIRONMENTAL PROTECTIVE ASSEMBLY

Summary

	7.1 Phase I	7.2 Phase II
Material Cost		
Labor Cost		
Total Cost		

STATOTHR

Phase I 7.1

Material Cost

Miscellaneous Materials	$500.00

Phase II 7.2

Material Cost

Miscellaneous Materials	$500.00

Phase I 7.1

Direct Labor Cost

STATOTHR

Classification	Rate	Hours	Amount
Mechanical Engineer			
Pattern Designer			
Model Maker			
Draftsman			
Technician, Assy.			
Technician, Test			
Stitcher			
Cementer			
Machinist			
Link Net Gridder			
Link Net Assembler			
Quality Assurance Tech.			
Mark & Cut			
Molding			
Totals			

Phase II 7.2

Direct Labor Cost

STATOTHR

Classification	Rate	Hours	Amount
Mechanical Engineer			
Pattern Designer			
Pattern Grader			
Draftsman			
Technician, Assy.			
Technician, Test			
Stitcher			
Cementer			
Machinist			
Link Net Gridder			
Link Net Fabrication			
Link Net Assembly			
Mark & Cut			
Molding			
Quality Assurance Technician			
Totals			

I. INTRODUCTION AND SUMMARY

This design study was initiated for the purpose of analyzing and determining what improvements could be made to the S-1010 Pilot's Protective Assembly which was originally developed under Contract DC-1700.

The Contractor submitted a proposal under letter JEF-328-2435, 10 August 1971, covering a Design Study, Omni-environmental Protective Assembly. This was a two-phase proposal consisting of Phase I, Helmet, and Phase II, Coverall and Gloves.

Contract DC-1714 was awarded, effective 15 September 1971, for Phase I, Helmet.

Inputs from the operating locations; including Headquarters units, SAC units at Davis-Monthan AFB, and Beale AFB, and the ADC operated pressure suit depot at Tyndall AFB, were used as the basis for design criteria for the prototype helmet to be developed under the provisions of the contract.

Major emphasis in design was placed in the following areas:

A. Improved Field of Vision

B. Improved Head Mobility

C. Improved Comfort

D. Improved Operating Functions

E. Improved Coverall Interface

F. Improved Maintainability

The evaluation of the prototype helmet (see attached photographs), conducted by the contractor, the headquarters project engineer, field-servicing

I. INTRODUCTION AND SUMMARY (continued)

technicians and twenty-one pilot subjects indicates that the major goals of the design study were achieved, but that several areas should be further improved before the design is adopted as a new standard. These areas include:

1. Better helmet holddown during the pressurized mode.
2. Bailer-bar type visor operation without compromise of the loss of downward visibility gained in the prototype.
3. An acceptable feeding port.
4. Improved electrical leads design at helmet shell interface and relocation to left side of manifold plate.

These design changes should be included in any follow-on helmets, but in conjunction with a program which will include coverall design changes to provide the necessary interface with the helmet and the airframe in order to achieve a flight configuration.

II. DISCUSSION

The study objective was to develop a design for an improved helmet for use in an omni-environmental protective assembly, and to fabricate a prototype helmet suitable for evaluation in a low pressure chamber.

The helmet for the Pilots Protective Assembly S-1010 was used as the basis for the design study. From this base, design effort was concentrated on the specific areas outlined in proposal JEF-328-2435, Para. 4.1. Some additional changes have also been made to increase the capabilities of the helmet.

II. DISCUSSION (continued)

Following is a summary of the changes incorporated in the design study and prototype unit.

A. Visibility

Increased visibility in the vertical plane has been obtained by the following steps:

1. The shell has been re-designed to allow better location of the subject's head in relation to the visor opening.
2. The vertical chordal distance or length of the visor has been increased. This allows a greater angle of visibility by making the helmet shell opening the limiting factor for visibility rather than the transparent area of the visor.
3. The breathing regulator has been removed from the suit and installed in the back section of the helmet.
4. The visor actuating lever has been changed from a bar across the helmet between the visor pivot points to a knob located on the left pivot point only. This puts the actuating lever completely out of the visible area.

B. Head Mobility

Better head mobility has been realized by:

1. Re-designing the helmet ring bearing. The new design uses larger diameter balls in a true thrust bearing configuration to give less frictional resistance to rotation.

II. DISCUSSION (continued)

B. Head Mobility (continued)

2. The helmet ring bearing is held in position in relation to the suit by using a cord woven from the bearing to loops located at the helmet disconnect.

This cord extends around the full circumference of the bearing and helmet disconnect. This suspension allows easier mobility in the vertical plane as well as a more even support of the bearing to reduce deformation of the bearing races, thereby reducing friction and binding problems of bearing rotation.

C. Helmet Comfort and Ventilation

Helmet comfort and ventilation have been increased by using a new concept in helmet liners. Instead of a relatively thick molded foam pad with a cover of tightly woven nylon, the new liner uses three materials stitched together to form a lightweight sandwich construction. This design also allows the liner to adjust to all head sizes, thus eliminating sizing problems associated with the molded liner.

The interior material of this sandwich construction is an open weave red nylon tricot backed by 5/16" thick polyurethane foam. The material in the middle is a 3/16" thick white polyethylene foam which has good shock absorbing qualities.

II. DISCUSSION (continued)

C. Helmet Comfort and Ventilation (continued)

The external material -- which is also used on the inside of the earcups -- is black "Curon". This material is actually a fine Velcro pile with a light foam backing.

Between the center head section and the earcup sections are two narrow panels. These panels have large openings in the polyurethane foam and have inner and outer covers of open mesh to enhance ventilation of the liner. They also allow the earcup sections to move in relation to the center head section to accommodate various head sizes. Leather earseals are used and are backed with fine Velcro hook. Thus the earseals can be adjusted simply by pressing them in the desired position on the "Curon" lining in the inside of the earcups.

D. Emergency Visor Defogging

The prototype helmet being fabricated will be supplied with a defogging system using the spray bar which directs the oxygen over the visor. This method of providing emergency fogging has its precedence in other systems, including the S901 J PPA and the standard USAF A/P22S-6 Flying Outfit. It was not a compatible system for the S-1010 PPA because of the low pressure at which oxygen was introduced into the oral nasal cavity.

II. DISCUSSION (continued)

E. Hypoxia Indicator

The possibility of including an hypoxia indicator in this helmet has been considered. It is one reason why a 19-pin connector was chosen for the communications/electrical cord penetration. The sensor and its receptacle (approximately 1/2" diameter x 1-1/4" long) would most likely be mounted on the face barrier in a position determined by testing to give the most reliable results. The electrical connections would be routed through the face barrier to the connector in a manner similar to that used for the microphone wires. (See Bechman ATO-1001-B). Delivery of an hypoxia indicator in the prototype helmet was not a requirement under the contract.

F. Visor Anti-Reflectance Coating

Investigations have shown that a process is available by which an anti-reflectance coating can be applied to a plastic visor. However, application of this coating cannot be considered until an alternate method of heating visors, such as imbedding heating wires in a laminated visor, has been perfected, since the anti-reflectance coating and gold coating cannot both be applied.

G. Helmet Locking

The visor actuating lever has been changed to a knob located at the left pivot point of the visor. This knob allows easy

II. DISCUSSION (continued

G. Helmet Locking (continued)

one-hand operation of the visor. A new lip-type seal mounted on the visor makes this new latching method possible. The seal utilizes internal helmet pressure to increase seal effectiveness between the visor and helmet shell. Therefore, the initial sealing force does not have to be as high as that required by present static seals so that a knob, rather than the current high leverage actuating bar is sufficient.

A latch to lock the visor in the open position is also included as an integral part of the new actuating mechanism.

H. Face Barrier and Face Seal

The face barrier and face seal remain relatively unchanged at present. The only change has been in the material used on the periphery of the barrier. This material should result in better cementing and easier removal of the face seal.

Related to this, however, are changes made in the take-up mechanism to provide a smoother and easier operating adjustment of the face seal.

A tentative design for a new type face barrier has been conceived, but not included in the prototype. This design would allow the face barrier to be easily pressed into position or pulled out for replacement. No cementing would be required.

II. DISCUSSION (continued)

I. Helmet Disconnect

The helmet disconnect has been completely redesigned. Instead of a complicated latching mechanism built into cumbersome hardware, a simple light-weight connection utilizing nearly all software instead of hardware has been designed. A solid ring is stitched into the neck opening of the suit. The helmet has a sealing surface stitched at the bottom of the pressure retaining bladder. The covering over this sealing surface has a steel cable stitched into it at the top and also at the bottom. These steel cables have a circumference somewhat less than the circumference of the steel ring in the suit. The bottom cable is split so that it can be slipped over the ring in the suit and then locked in place with a latching mechanism. This latch axially locks the suit ring and bottom cable to connect the helmet to the suit and at the same time wraps the sealing surface on the helmet around the fabric surrounding the suit ring to give an effective gas tight seal.

This simplified construction also increases the effective inside diameter of the helmet by approximately 5/16" for easier donning and doffing.

J. Feeding Port

Changes in the helmet to increase visibility, comfort, and mobility have made normal placement of the feeding port

II. DISCUSSION (continued)

J. Feeding Port (continued)

impractical. A feeding port was designed and located to the right side of the helmet. A curved stainless steel feeding tube with a covering of Teflon was used for ease of entry through the sealing door and comfort in the subject's mouth.

This system proved, from the outset, to be difficult to operate and an alternate method was proposed, but not fully engineered for the prototype helmet.

K. Communication/Electrical Cord Penetrations and Routings

A standard 19-pin microdot hermetically-sealed communications/electrical entrance fitting has been incorporated in the design. It was located at the right rear of the helmet allowing entrance and routing of all required wiring at one easily accessible location. The 19-pin configuration has been chosen so that several spare entrance connections will be available to accommodate any future wiring needs.

L. Microphone Mounting

The basic microphone mount will be attached to the helmet face barrier inside the helmet as currently used on the helmet of Pilots Protective Assembly S-1010. The microphone itself, however, will be attached by means of a newly designed

II. DISCUSSION (continued)

L. Microphone Mounting (continued)

ball-swivel mounting. This mounting allows easy adjustment of the microphone through a full 360° revolution in the horizontal plane and a 15° motion up or down in a vertical plane. It also allows forward or backward tilt of 15°. All of these adjustments can be made with light finger pressure only, thus making microphone adjustment easier and more exact.

M. Additional Design Features

1. The breathing regulator has been moved to a position in the rear of the helmet. As part of the design for this change, a manifold has been made which allows the breathing regulator to be replaced in a few minutes time without even the necessity of having the subject remove the helmet. This is done by mounting the regulator on a manifold which interfaces with the internal oxygen and sensing lines by using O-rings to seal the interface. By means of only two screws, this entire manifold and regulator unit can be removed and a new one inserted.

2. The sunshade is held in place by a friction lock of improved design. This lock is a clamping ring which rotates around the sunshade pivot and to which the sunshade is attached. By simply using the adjusting screws located in the clamping ring, the desired friction force for proper sunshade tension can be obtained.

III. PROTOTYPE EVALUATION

Evaluation of the prototype was conducted at three operating locations including the Headquarters unit, Davis-Monthan AFB, and Beale AFB.

Results of the evaluation by twenty-one pilots using the Subjective Evaluation Sheet (Attachment 1.) to record results, indicated the following:

A. Field of Vision

1.	Unpressurized,	Improved	19
		Same	1
		No Comment	1
2.	Pressurized,	Improved	15
		Same	3
		Worse	2
		No Comment	1

B. Head Mobility, Horizontal

1.	Unpressurized,	Improved	18
		Same	3
2.	Pressurized,	Improved	14
		Same	5
		Worse	2

C. Head Mobility, Vertical

1.	Unpressurized,	Improved	3
		Same	7
		Worse	11

III. PROTOTYPE EVALUATION (continued)

C. Head Mobility, Vertical (continued)

2.	Pressurized,	Improved	3
		Same	7
		Worse	11

D. Comfort (all elements combined)*

1.	Unpressurized,	Improved	59
		Same	57
		Worse	8
		No Comment	2

*Includes ventilation, helmet holddown, weight distribution, suspension system, spray bar pattern.

E. Operating Components (all elements combined)**

1.	Unpressurized,	Improved	14
		Same	22
		Worse	46
		No Comment	2

** Includes visor opening, closing and locking, sunshade operation, feeding port function, and coverall/helmet disconnect function.

III. PROTOTYPE EVALUATION (continued)

F. Coverall Interface (all elements combined)***

1.	Unpressurized,	Improved	23
		Same	36
		Worse	3
		No Comment	1

*** Includes O_2 Hose Routing, Electrical Leads, and Manifold Location.

In the major areas of concern for normal operation, i.e., Field of Vision, Head Mobility, and Comfort Unpressurized the acceptance comments were: 74, Improved; 39, Same, and 2, Worse. In the pressurized mode, it was evident that the interface of the helmet with the coverall and helmet holddown assembly was the major contributing factor in evaluation results which showed a Worse condition in eleven, Same in seven, and only three Improved out of twenty-one subjects.

One other area which proved to be of major concern in the evaluation was the Visor Opening, Closing and Locking Mechanism. Inputs from the operating units gave no indication of the degree of reliance upon the use of visor-operating bailer bar of the current S-1010 Helmet for assistance in turning and nodding the head. The lack of the bailer bar on the prototype helmet prompted sixteen out of twenty-one subjects to indicate preference for the bailer bar mode for closing the visor and commenting that they felt they would lose

III. PROTOTYPE EVALUATION (continued)

some mobility and field of vision without the bailer bar to use as an assist in turning and nodding.

The microphone mount described under Section L. was judged to be more complex and critical to adjust than was practically necessary. It was replaced with the current S-1010 type of mount prior to subjective evaluation by the pilot subjects with the approval of the project engineer.

Considering the fact that the helmet was adapted to one coverall size and was fitted with one helmet liner size only, it should be recognized that an optimum fit was not attainable in many cases and that some decisions as to whether the subject found the conditions the same or worse could have been influenced by less than optimum fit.

IV. CONCLUSIONS

1. The Contractor concludes that the prototype helmet demonstrated a definite improvement in the important areas of Field of Vision, Mobility, Donning and Doffing, Weight Reduction, and Comfort.

2. Problem areas not fully resolved include:

A. Feeding Port Location

B. Electrical/Communications Connector Engagement (External)

C. Downward Vision and Mobility while Pressurized

D. Earphone Adjustment in Helmet Liner

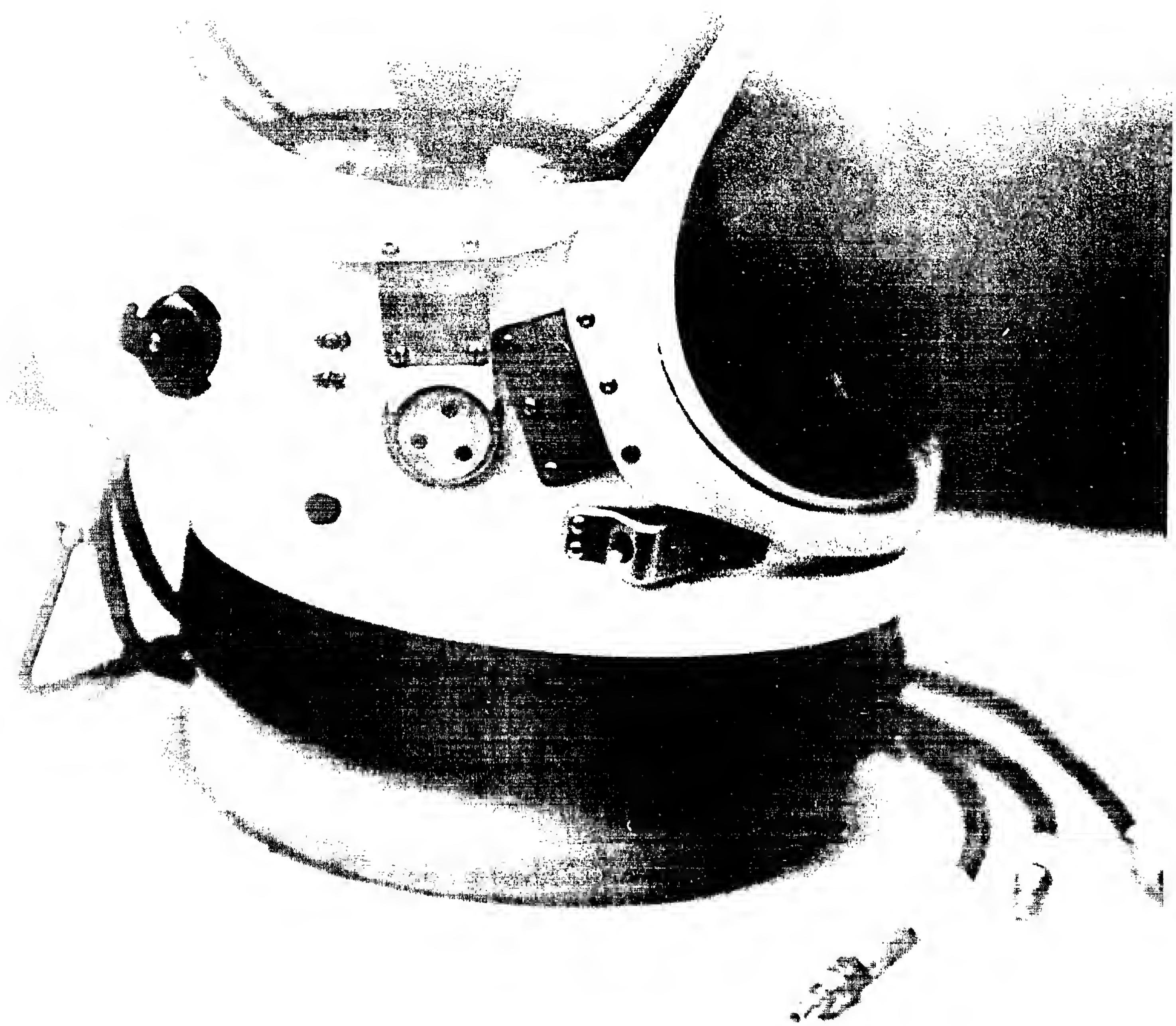
IV. CONCLUSIONS (continued)

3. The problem areas cited in Paragraph 2 can be resolved with additional effort.

V. RECOMMENDATION

1. The Contractor recommends that a program be established which will provide helmets for flight evaluation.

2. The availability of modified S-1010 PPA's should be considered in the program.



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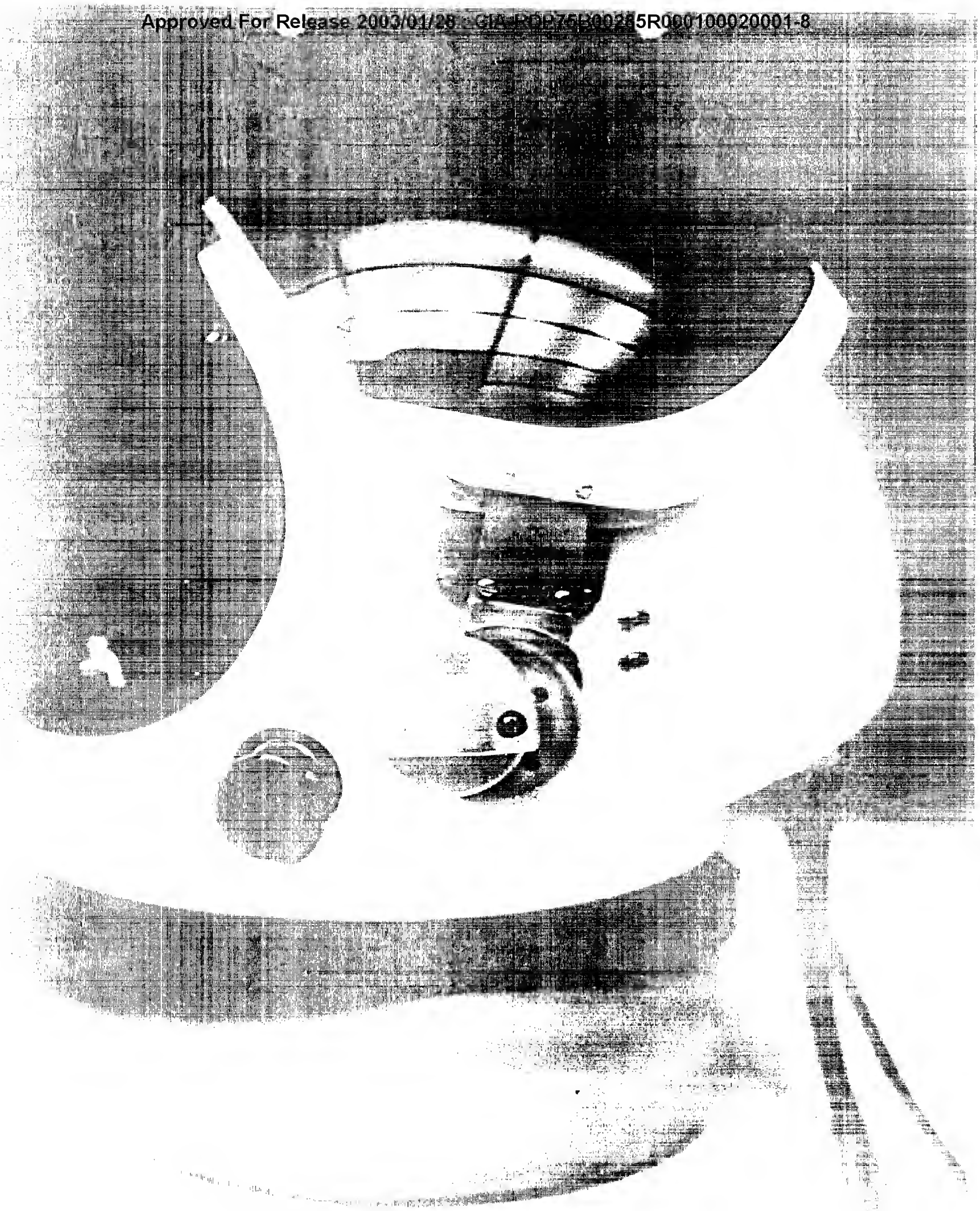

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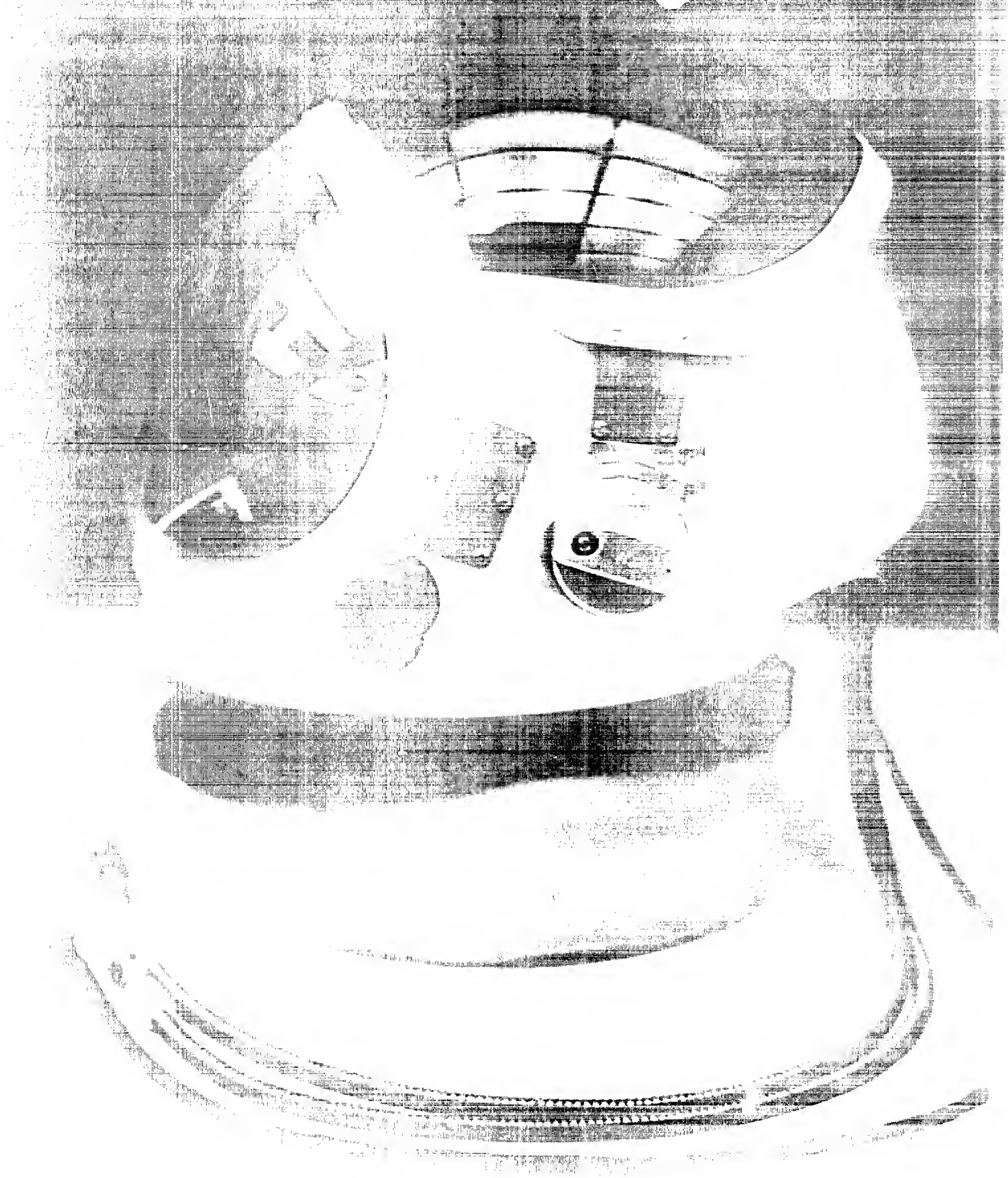

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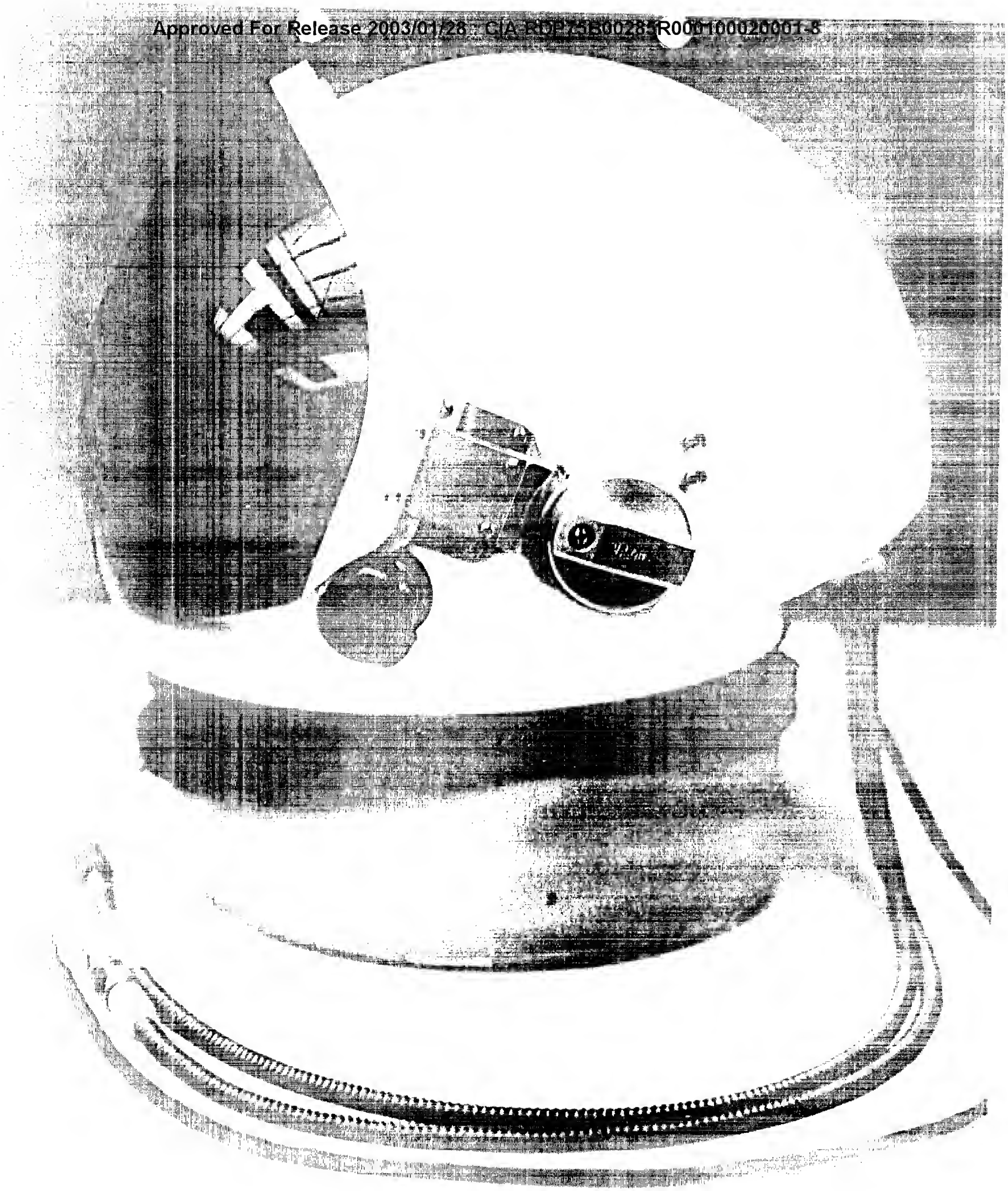

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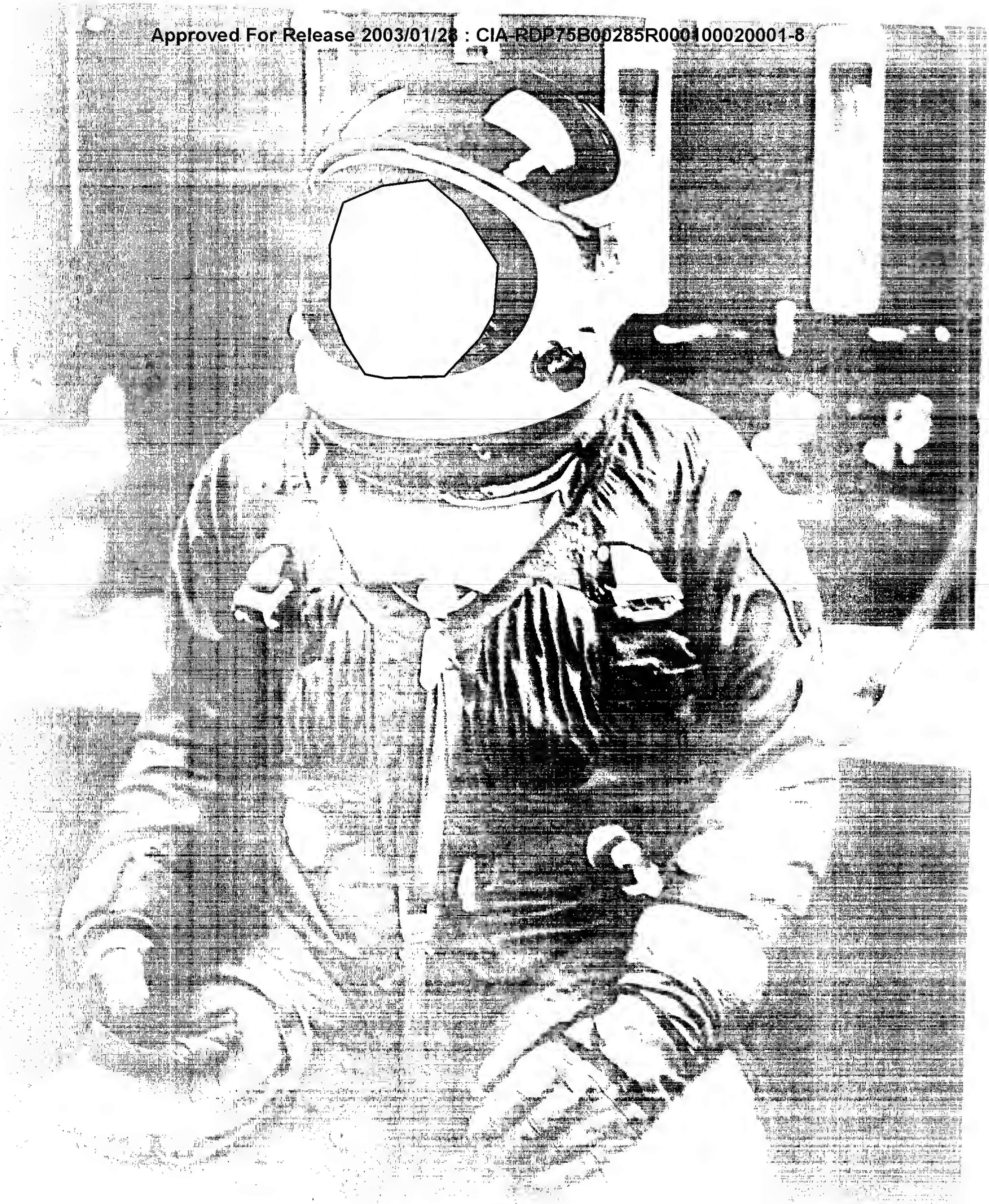

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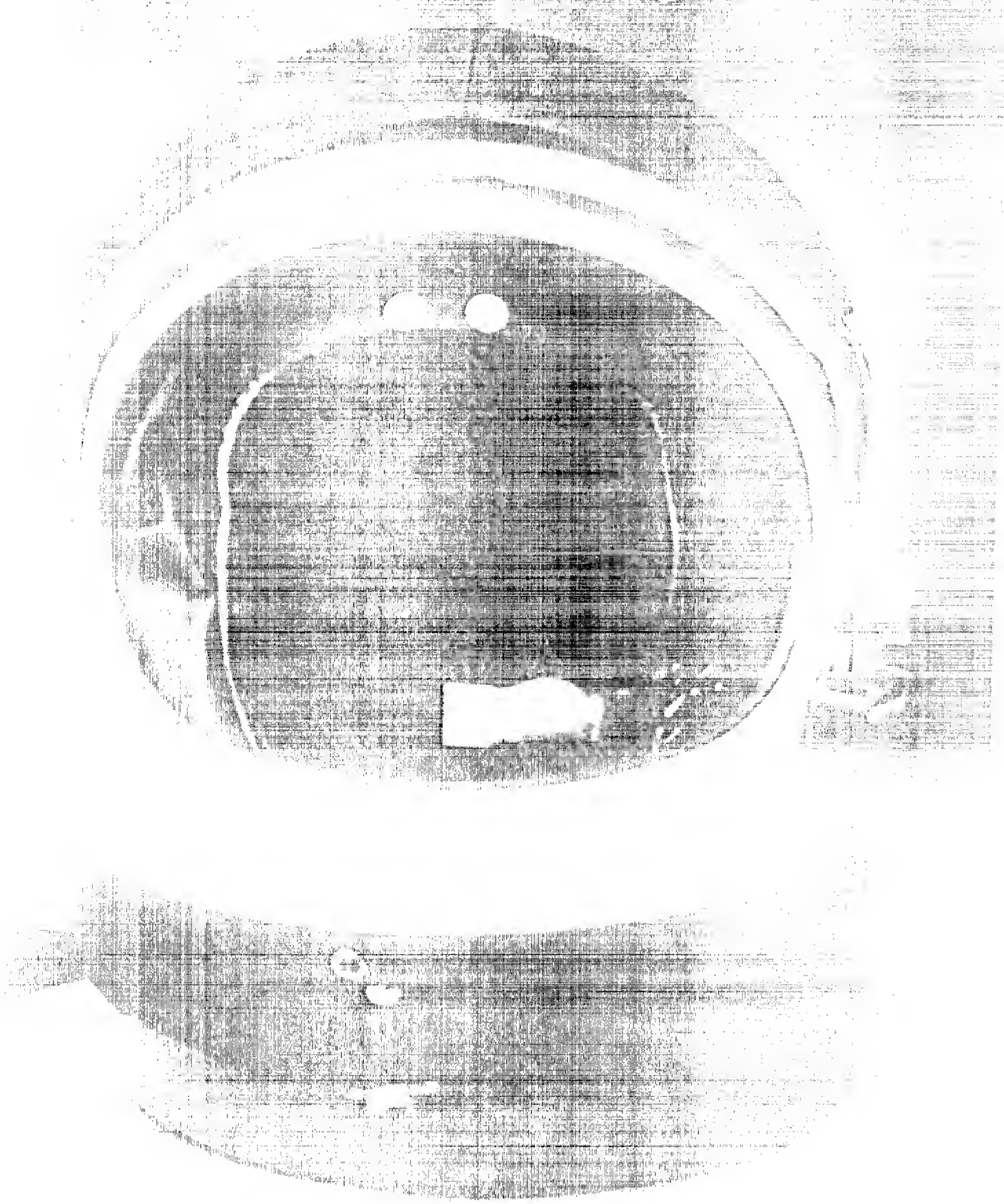

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